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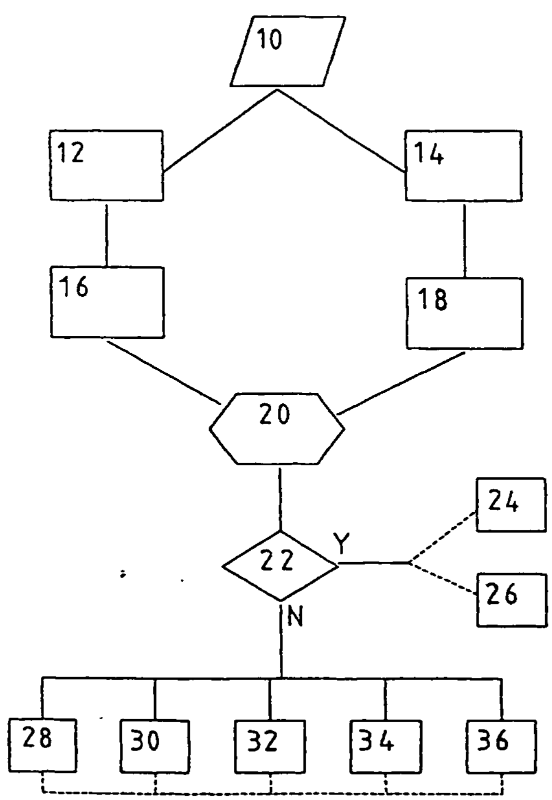
(54) Title: A METHOD OF SUPERVISING OR CONTROLLING A DEVICE BY MEANS OF A COMPUTER MODEL



(57) Abstract: The invention concerns a method of supervising or controlling a real device (4) by means of a computer model (6) of the device. The real device (4) is operated (12) and the computer model (6) is run (14). The device (4) and the computer model (6) are thereby fed with (10) and/or execute the same data. Parameters concerning the state of the device (4) are registered (16). The corresponding parameters concerning the state of the computer model (6) are determined (18). The parameters concerning the state of the device (4) are compared (20) with the corresponding parameters concerning the state of the computer model (6). An assessment is done (22) whether deviations between said parameters concerning the state constitute normal deviations. At least one measure is carried out (28-34) when a non-normal deviation is detected.

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A method of supervising or controlling a device by means of a computer model.

BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention concerns a method of supervising or controlling a real device be means of a computer model. Such methods are already known. For example, the document DE-A-19 750 315 shows a method for controlling for example an excavator by means of a computer model of a factual and a desired ground formation that the excavator works on. The document does however not describe that any comparison is done between variables concerning the state of the excavator and variables concerning the state of a corresponding computer model of the excavator. The document is thus not directed to the detection of errors in the operation of the excavator.

EP-A-0 684 534 describes an adaptive control system. The system may be used for controlling different kinds of devices. The system is primarily used in control systems where a cyclic error signal occurs. According to the document, the control system comprises the creation of a model of a cyclic system error. The document does however not describe that a computer model of the device is compared with a real device.

There is a need to detect errors or deviations from the normal operational state of a device. Such a need exists within many different technical fields. In the description below, primarily an application of the present invention for supervising or controlling an unmanned aircraft is described. The invention may however be used within other kinds of technical systems. The invention is particularly suitable for detecting sources of error in a technical system. The invention is further directed to carrying out different

measures at the detection of errors or deviations in such technical systems. An unmanned aircraft, or another technical system, often have built-in tests, so-called "built in test", which makes it possible to detect certain predictable possible errors. Furthermore, information about such detected errors may be transmitted to an operator. However, errors or imperfections of the system, which are not detected by the built-in test functions, may exist. Such errors or irregularities may for example consist of unpredictable error functions, which have not been taken into account during the design of the built-in test functions.

SUMMARY OF THE INVENTION

The purpose of the present invention is to achieve a method for in a relatively simple manner being able to supervise or control a device when such unpredicted errors or deviations occur. A further purpose is thereby to carry out suitable measures when such errors or deviations are detected.

This purpose is achieved with the method according to the invention, according to which method a real device is supervised or controlled by means of a computer model of the device, wherein the real device is operated and is thereby fed with and/or executes data that control the operation of the device,

the computer model of the device is run and is thereby fed with and/or executes the same data as the device,

parameters concerning the state of the device are registered for at least a period of time of operation of the device and the corresponding parameters concerning the state of the computer model are determined,

the parameters concerning the state of the device are compared with the corresponding parameters concerning the state of the computer model such that deviations between the parameters concerning the state of the device and the parameters concerning the state of the computer model are determined,

an assessment is done concerning if said deviations constitute normal deviations,

wherein at least one measure is carried out when at least one non-normal deviation is detected.

Since the computer model and the device are run and fed with the same data, the device and the computer model have, during normal operation of the device without errors, principally the same parameters concerning the state. Certain deviations may however exist also during normal operation. According to the method, it is thus taken into account whether deviations are to be considered as normal or not. When a non-normal deviation occurs, a suitable measure is carried out. In this manner a reliable supervision or control of the operation of the device is achieved according to the invention.

According to a preferred method according to the invention, the assessment concerning whether a deviation is normal is done by comparing the deviation with previously known normal deviations. Such normal deviations may in advance have been taken into account and input into a computer, which then compares such normal deviations with the detected deviations. In this manner, an assessment may be done as to whether the deviations constitute normal or non-normal deviations.

According to a further preferred embodiment of the invention, said method is performed a plurality of times, wherein the result from this plurality of performed methods is analysed for the determination of systematic deviations. When such systematic deviations have been determined, suitable measures may be carried out in order to correct for these deviations if this appears to be necessary.

According to a further preferred embodiment of the invention, the device and the computer model of the device are run time synchronously in real time. The device may thus be continuously supervised during the time it is operated. Suitable measures may thus directly be carried out when non-normal deviations are detected.

According to a further preferred embodiment according to the invention, the device is controlled and/or supervised from an observation position, wherein the device during operation is located at a distance from said observation position and the device comprises means which transfer parameters concerning the state to said observation position. The device may thus be supervised from a position, which is located at a long distance from the device itself. This is for example advantageous when the device constitutes an unmanned aircraft, which may be located at a long distance from an operator.

According to still another preferred embodiment according to the invention, the computer model of the device continues to run also in case an error occurs in the transfer of the said parameters, concerning the state, between the device and the observation position such that an estimation of the parameters concerning the state of the device is obtained by means of the corresponding parameters concerning the state of the computer model, even if no complete transfer of parameters concerning the state or no transfer at all is the case between the device and the observation position. Since the computer model generates parameters concerning the state which during normal conditions agree with the parameters concerning the state of the device, the parameters concerning the state of the device, for example the position of the device, may thus be estimated by means of the computer model even if the communication between the device and for example an operator is cut off.

According to a further preferred method according to the invention, the device is first operated and said parameters concerning the state of the device are registered, wherefore the computer model is run and the previously registered parameters concerning the state of the device are compared with the corresponding parameters concerning the state of the computer model. According to this embodiment of the invention, it is thus not necessary to operate the device time synchronously in real time with the computer model.

The device may thus first be operated, then the registered parameters concerning the state of the device may be compared with parameters concerning the state of the computer model. For example systematic deviations in the behaviour of the device may thereby be detected at a later point in time than the point in time when the device was operated.

According to still another preferred method according to the invention, said measure comprises the determination of a source of error on the basis of the detection of at least one non-normal deviation. By analysing the detected deviation, a source of error may thus be determined. Thereby it is possible to correct or compensate for the determined source of error.

According to still another preferred method according to the invention, said measure comprises a correction of the operation of the device. This method is particularly advantageous when the device and the computer model of the device are operated time synchronously in real time. A correction may thereby immediately be carried out for, for example, a detected source of error.

According to a further preferred method according to the invention, said measure comprises the generation of a warning message to an operator. It may thus be drawn to the attention of an operator who supervises the operation of the device that a non-normal deviation is the case. The operator may thereafter take suitable measures.

According to a further preferred method according to the invention, said measure comprises an interruption of the operation of the device. It may for example be the case that certain kinds of detected errors or deviations are of such a nature that the operation of the device should be stopped. According to the method, for example different non-normal deviations may be classified. If a non-normal deviation is of a certain kind, the operation of the device is interrupted.

According to a further preferred embodiment of the method according to the invention, the data that the device and the computer model are fed with comprise commands input by an operator and/or automatically generated commands. An operator may for example from said observation position control the device. It is also possible that the device is programmed in advanced to automatically carry out measures under certain conditions.

According to a further preferred method according to the invention, said device is an unmanned aircraft. Since such an aircraft does not have a pilot who is located in the aircraft, it is particularly important to still be able to detect non-normal deviations in the behaviour of the aircraft.

SHORT DESCRIPTION OF THE DRAWINGS

The present invention will now be explained by means of an example of a method according to the invention and with reference to the annexed drawings.

Fig 1 shows schematically components, which are included in the method according to the invention.
Fig 2 shows schematically a flow chart of an embodiment of the method according to the invention.

DETAILED DESCRIPTION OF A METHOD ACCORDING TO THE INVENTION

Fig 1 shows very schematically an unmanned aircraft 4. The aircraft comprises means 5 for transmitting information to an observation position 8. Furthermore, the figure shows a computer model 6 of the device 4. The computer model 6 is suitably implemented in a computer, which is provided at the observation position 8. It is also possible that the computer model 6 is located at another location than at the observation position 8. At the observation position 8 there may be an operator. It is also possible that the whole method

according to the invention is performed automatically, i.e. without the presence of an operator.

Fig 2 shows schematically a flow chart for a method according to the invention. The real device 4 is operated such as is symbolised by the block 12. Furthermore, a computer model 6 of the device is run such as is symbolised by the block 14. At block 10 the device 4 is fed with data which control the operation of the device 4. Such data may for example consist of commands input by an operator. The device 4 may also execute automatically generated commands. If the device 4 is an unmanned aircraft, the commands may for example include the course of travel, a change of the course of the aircraft, the speed of travel, commands for carrying out missions, a change of the flight altitude etc. Such control commands may be programmed in the aircraft 4 before it starts its flight. It is also possible that an operator supplies changed commands to the aircraft 4 during the flight.

According to the invention, the computer model 6 of the device is fed with and executes the same data as the device 4. In block 16, parameters x_4, y_4, z_4 concerning the state of the device 4 are registered. These parameters x_4, y_4, z_4 concerning the state may for example include the position, the speed, the direction of travel of an aircraft 4, different parameters concerning the engine which propels the aircraft 4 and other similar relevant parameters. These parameters x_4, y_4, z_4 concerning the state may for example be transmitted to the observation position 8. In block 18, the corresponding parameters x_6, y_6, z_6 concerning the state of the computer models 6 are determined.

In block 20, the parameters x_4, y_4, z_4 concerning the state of the device 4 are compared with the corresponding parameters x_6, y_6, z_6 concerning the state of the computer model 6. Deviations between the parameters concerning the state of the device 4 and the parameters concerning the state of the computer model 6 are thereby determined. In block 22 it is decided whether said deviations constitute normal deviations. The decision whether a

deviation is to be considered as normal may for example be done by comparing the deviation with already known normal deviations. Such normal deviations may be based on natural phenomena such as winds, drift in different systems onboard the aircraft 4, and so on. Since the character of such sources of error is known, they may for example be identified as normal by supervising these deviations during a period of time of operation of the device 4 and the computer model 6. The comparison in block 20 and the determination whether a deviation is normal in block 22 may suitably be performed by a computer. Such a computer may be pre-programmed in order to identify normal deviations. If the deviation is normal, which is marked with Y in Fig 2, no measure needs to be carried out and the operation of the device 4 may continue, which is marked by block 24. In certain cases some adjustment may be performed even if the deviation is normal. This is marked by block 26. Such a normal adjustment may for example be that the operation of the aircraft 4 is adjusted in order to compensate for drift for example caused by the wind.

However, technical errors or other disturbances may cause deviations, which are not to be considered as normal. The detection of a non-normal deviation is marked by N in Fig 2. The detection of at least one such non-normal deviation means that at least one measure will be carried out. Such a measure may, according to block 28, be the determination of a source of error on the basis of the detection of at least one non-normal deviation. Such a detection of a source of error may be done by for example different recursive algorithms that reconstruct the cause of the detected deviation. Such error identifying algorithms are known per se. An example of such error identification comprises so-called Kalmanfiltering.

In block 30 said measure means that a correction of the operation of the device is carried out. As is indicated by hatched lines in Fig 2, block 28 may be combined with for example block 30. This means that after that a source of error has been determined, a correction of the operation of the device 4 may be carried out in order to correct for the error, which has been discovered. Another

possible measure, symbolised by block 32, constitutes the generation of a warning message to an operator. Such a warning message may for example be generated if the source of error has not been able to be determined or if the operation of the device 4 is not corrected automatically after that the source of error has been determined. According to block 34 said measure comprises an interruption of the operation of the device 4. The detected deviation may be such that it is not meaningful to continue the operation of the device 4. For example, the deviation may be such that a correction cannot be carried out. The most suitable measure may thereby be that the operation of the device 4 is stopped.

Block 36 symbolises another measure, which is carried out when a non-normal deviation is detected. Such a measure may for example consist in that improvements with the purpose of avoiding the error are carried out after that the aircraft 4 has landed. It may for example the case that certain detected non-normal deviations cannot be identified or cannot be corrected during the operation of the aircraft 4. Further investigations and measures may thereby be carried out after the landing.

According to the invention, either only one of the measures 28-36 may be carried out when a non-normal deviation is detected. It is also possible to carry out a plurality of the measures 28-36.

The method according to the invention may be performed a plurality of times. The result from these performed methods may thereby be analysed. This makes it possible to determine systematic deviations. These detected systematic deviations may form the basis for a corrected construction of the device 4 or of the operation of the device 4.

The device 4 and the computer model 6 may be operated time synchronously in real time. It is however also possible that parameters x_4, y_4, z_4 concerning the state of the device 4 are first registered, during for example an airborne mission, wherefore the computer model 6 is run at a later occasion. The previously

registered parameters x_4, y_4, z_4 concerning the state of the device 4 are thereby compared with the corresponding parameters x_6, y_6, z_6 concerning the state of the computer model 6.

An advantage with the method according to the invention is that with the help of the computer model 6, the parameters x_4, y_4, z_4 concerning the state of the device can be estimated even if the transfer of the parameters x_4, y_4, z_4 concerning the state between the device and the observation position 8 is cut off.

It should be noted that even if above only three parameters x, y, z concerning the state have been indicated, the number of parameters concerning the state may of course be essentially larger than this.

The method according to the invention does not only concern aircrafts but may be used for supervising or controlling many different kinds of technical systems.

The present invention is not limited to the described method but may be varied and modified within the scope of the following claims.

Claims

1. A method of supervising or controlling a real device (4) by means of a computer model (6) of the device, wherein

the real device (4) is operated (12) and is thereby fed (10) with and/or executes data that control the operation of the device (4),

the computer model (6) of the device (4) is run (14) and is thereby fed (10) with and/or executes the same data as the device (4),

parameters (x_4, y_4, z_4) concerning the state of the device (4) are registered (16) for at least a period of time of operation of the device (4) and the corresponding parameters (x_6, y_6, z_6) concerning the state of the computer model (6) are determined (18),

the parameters (x_4, y_4, z_4) concerning the state of the device (4) are compared (20) with the corresponding parameters (x_6, y_6, z_6) concerning the state of the computer model (6) such that deviations between the parameters (x_4, y_4, z_4) concerning the state of the device (4) and the parameters (x_6, y_6, z_6) concerning the state of the computer model (6) are determined,

an assessment is done (22) concerning if said deviations constitute normal deviations,

wherein at least one measure is carried out (28-34) when at least one non-normal deviation is detected.

2. A method according to claim 1, wherein the assessment (22) concerning whether a deviation is normal is done by comparing the deviation with previously known normal deviations.

3. A method according to claim 1 or 2, wherein said method is performed a plurality of times, wherein the result from this plurality of performed methods is analysed for the determination of systematic deviations.

4. A method according to any one of the preceding claims, wherein the device (4) and the computer model (6) of the device are run time synchronously in real time.

5. A method according to any one of the preceding claims, wherein the device (4) is controlled and/or supervised from an observation position (8), wherein the device (4) during operation is located at a distance from said observation position (8) and the device (4) comprises means (5) which transfer parameters (x_4, y_4, z_4) concerning the state to said observation position (8).

6. A method according to claim 5, wherein the computer model (6) of the device continues to run also in case an error occurs in the transfer of said parameters (x_4, y_4, z_4), concerning the state, between the device (4) and the observation position (8) such that an estimation of the parameters (x_4, y_4, z_4) concerning the state of the device is obtained by means of the corresponding parameters (x_6, y_6, z_6) concerning the state of the computer model (6), even if no complete transfer of parameters (x_4, y_4, z_4) concerning the state or no transfer at all is the case between the device (4) and the observation position (8).

7. A method according to any one of the claims 1-3, wherein the device is first operated (12) and said parameters (x_4, y_4, z_4) concerning the state of the device are registered, whereafter the computer model (6) is run (14) and the previously registered parameters (x_4, y_4, z_4) concerning the state of the device (4) are compared with the corresponding parameters (x_6, y_6, z_6) concerning the state of the computer model (6).

8. A method according to any one of the preceding claims, wherein said measure comprises the determination (28) of a source of error on the basis of the detection of at least one non-normal deviation.

9. A method according to any one of the preceding claims, wherein said measure comprises a correction (30) of the operation of the device (4).

10. A method according to any one of the preceding claims, wherein said measure comprises the generation (32) of a warning message to an operator.

11. A method according to at least claim 4, wherein said measure comprises an interruption (34) of the operation of the device (4).

12. A method according to any one of the preceding claims, wherein the data that the device (4) and the computer model (6) are fed (10) with comprise commands input by an operator and/or automatically generated commands.

13. A method according to any one of the preceding claims, wherein said device (4) is an unmanned aircraft.

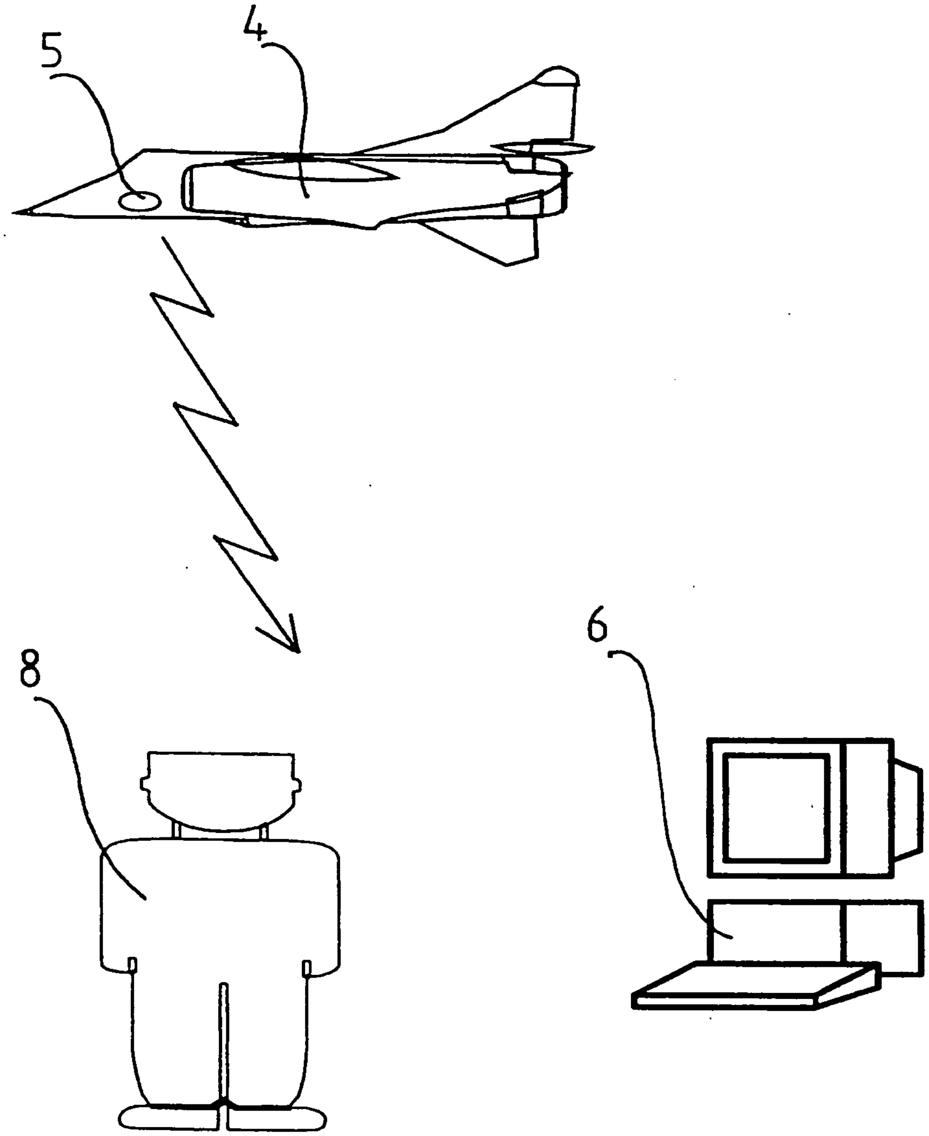

FIG 1

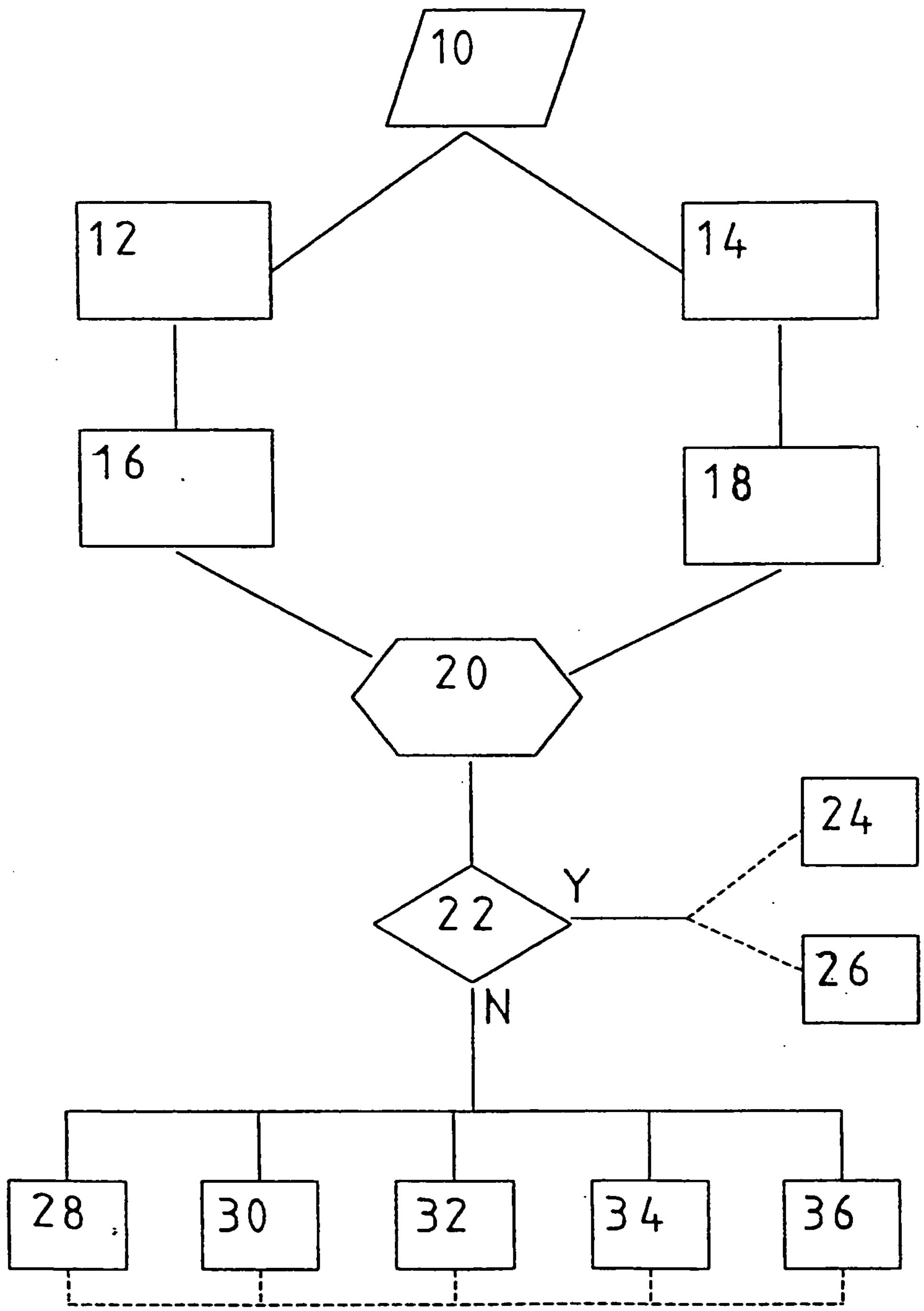

FIG 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/05787

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05B23/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 626 697 A (HITACHI) 30 November 1994 (1994-11-30) figures 1,13	1,2,4, 8-11
X	US 4 214 301 A (IBA DAIZO ET AL) 22 July 1980 (1980-07-22) the whole document	1,4,10
A	EP 0 845 722 A (WOODWARD GOVERNOR CO) 3 June 1998 (1998-06-03) column 6, line 45 -column 8, line 6	1
A	EP 0 883 046 A (CARRIER CORP) 9 December 1998 (1998-12-09) figure 5	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
6 September 2000	19/09/2000

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

...formation on patent family members

International Application No
PCT/EP 00/05787

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